DEFENCE R&D DÉFENSE

In-Situ Remediation Strategy Applied to Military Firing Positions Contaminated with Energetic Materials

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Outline

- Soil contamination
  - Firing Position
  - Target Area
  - Problematic
  - Decontamination techniques
- Goal of this research project
- Tests
  - Heat penetration tests
  - Small scale tests (laboratory)
  - Large-scale test (CFB Gagetown)
- Conclusion

Soil Contamination

- All military personnel have the responsibility to maintain a high standard of training, including weapons with live munitions
- Training on relatively small sites
- Contamination with residues of explosive materials accumulate :
  - Firing positions : incomplete combustion of gun propellant (70% of overall contamination in the first 20 cm of soil)
  - Target areas : dispersion of the explosive filling

Contamination at Firing Positions

- Example : Carl Gustav 84 mm antitank weapon

Deposition studies : **14%** (w/w) of **unburned NG** deposited behind the gunner

Contamination at Firing Positions

- Example : Legacy sites

After 25 years of inactivity :
> 4 000 mg/kg NG on soil surface.
Detection of NG up to 1 m deep.

Contamination at Target Areas

- Example : Unexploded ordnances (craking, corrosion) and low-order detonations

Problematic

- Some compounds :
  - Toxic
  - Persistent
  - Affect soil and water resources (fate and transport)
- Massachussetts Military Reservation (MMR) **closed** in 1999 by an order of the US EPA because of **RDX contamination in the drinking water** of the neighbourhood
- Regular maintenance of decontamination of the surface soils could reduce the environmental impacts

Decontamination Techniques* (Non-Exhaustive)

- Biological treatments
  - Aqueous phase bioreactor treatment
  - Composting
  - Landfarming
  - Phytoremediation
  - White rot fungus treatment
- Thermal treatment
  - Hot gas decontamination
  - Incineration (rotary kiln, deactivation furnace)
- Other techniques
  - Soil washing
  - Alkaline hydrolysis
  - Fire ecology (management of vegetation), prescribed burnings

*Federal Remediation Technologies Roundtable (2008), Remediation Technologies Screening Matrix and Reference Guide, Version 4.0, (http://www.frtr.gov/matrix2/top_page.html).

Goal of the Research Project

- To develop a technique that would allow the remediation of contaminated soils by energetic materials at firing positions.
- Should be:
  - Simple
  - Applicable in-situ (i.e. without the removal of the soil for treatment)
  - Inexpensive
- Facts
  - Explosives are organic compounds, they have a relatively low decomposition temperature
  - No vegetation at firing positions

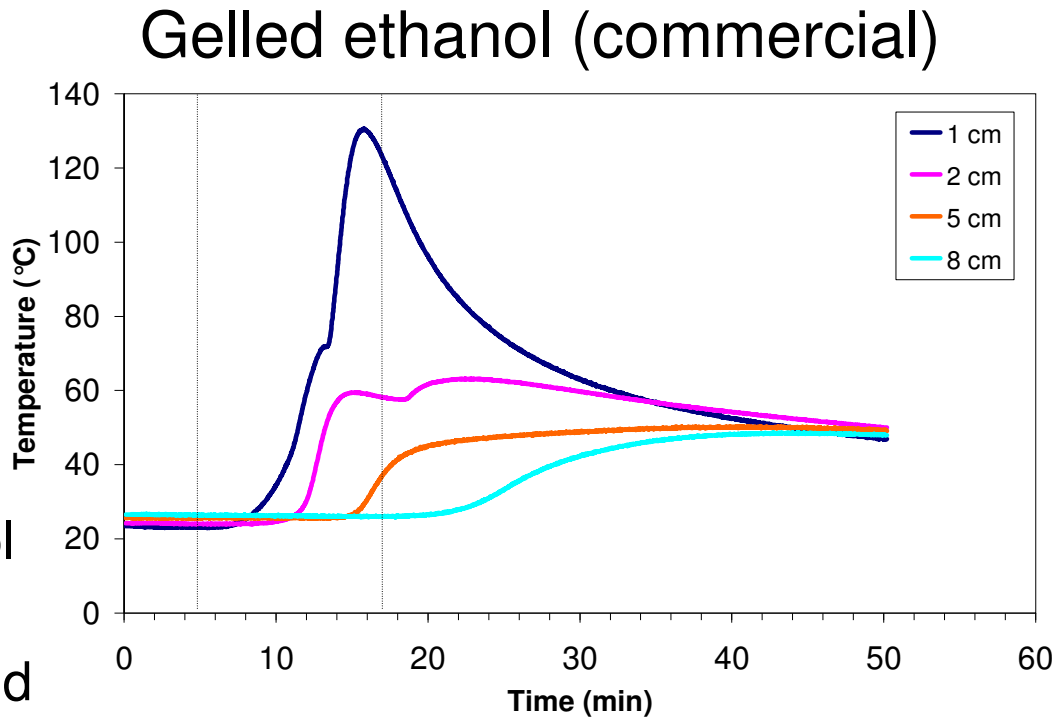
Destruction of Explosive Compounds

- Heat the soil beyond the thermal decomposition temperature of energetic materials
  - Combustion of a fuel which is :
    - Non-toxic (wildlife and plants)
    - Easy to manipulate
    - Possible to spread out and ignite

Heat Penetration Tests

Fuel tested :

- Ethanol
- Methanol
- Isopropanol
- Wood shavings
- Wood shavings soaked with ethanol
- Gelled methanol
- Gelled ethanol (home-made and commercial)



Maximum Temperature Reached during the Burning of Various Fuels on Sand

Fuel	Maximum temperature at various depths (°C)			
	1 cm	2 cm	5 cm	8 cm
Gelled ethanol (1.25 cm thick)	131	63	50	49
Gelled ethanol (1.25 cm thick) (duplicate)	106	72	52	51
Gelled ethanol (2.5 cm thick)	80	68	61	57
Gelled methanol (1 cm thick)	90	57	53	53
Wood shavings (3.8 cm thick)	25	22	22	22
Wood shavings (3.8 cm thick) soaked with ethanol	80	57	54	52
Ethanol (500 mL)	63	50	38	36
Isopropyl alcool (500 mL)	33	29	27	33
Methanol (500 mL)	28	28	27	33
1st cm of sand mixed with gelled ethanol (~ 1:1 v/v)	191	92	65	62
Home-made ethanol gel (with calcium acetate) (1.25 cm thick)	65	58	31	21
Home-made ethanol gel (with calcium acetate) (1.25 cm thick) (duplicate)	53	43	22	20
1st cm of sand mixed with home-made ethanol gel (with calcium acetate) (~ 1:1 v/v)	85	69	48	28
Activated carbon (50 mL) mixed with home-made gel (500 mL)	80	63	54	----

Laboratory Tests : Burning of Selected Fuels on Contaminated Dry Soil

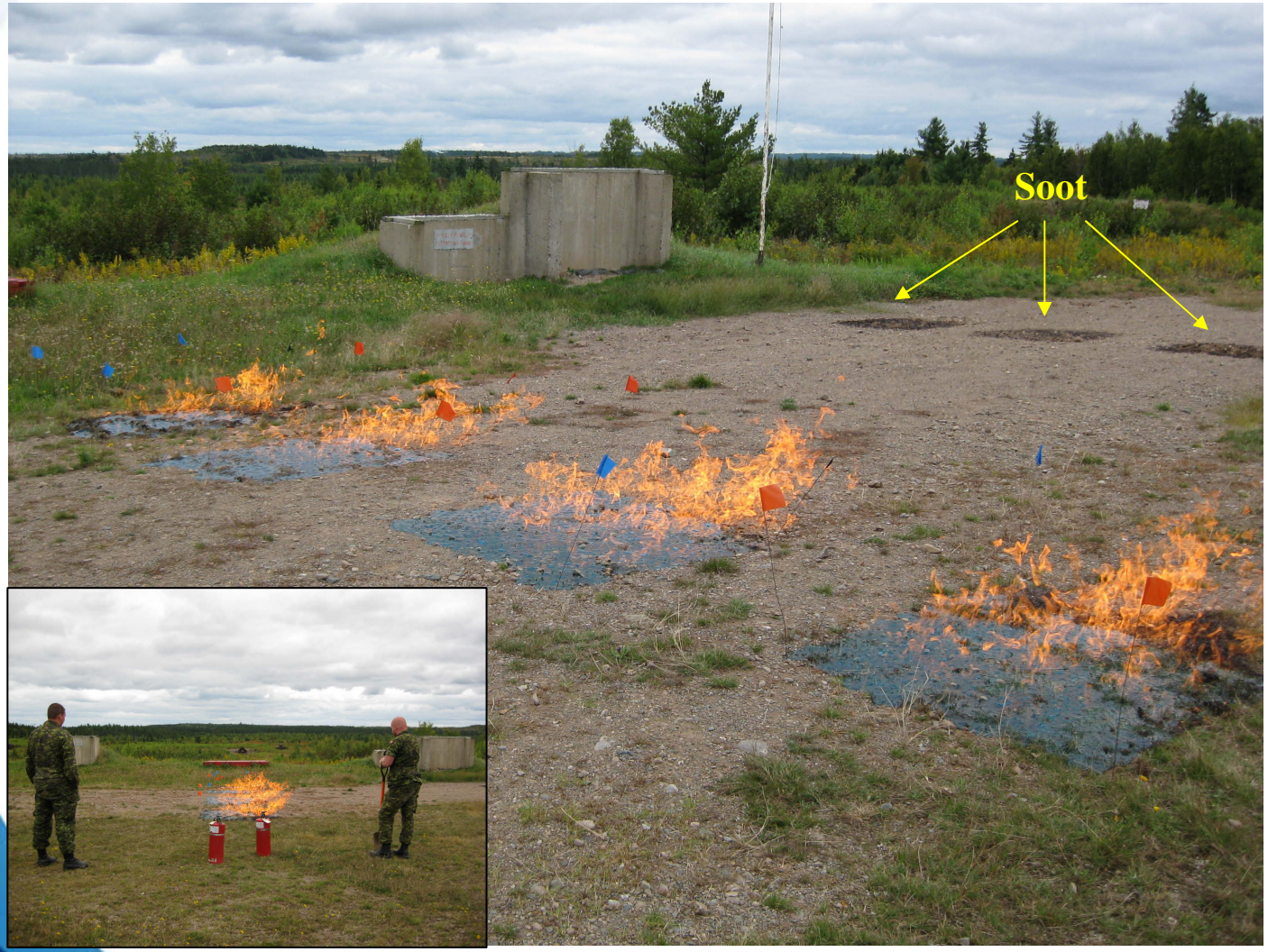
NG concentration in surface (0-1 cm deep) soil samples

Thermal process	[NG] (mg/kg) before	[NG] (mg/kg) after	Reduction (%)
2.5 cm gelled ethanol (commercial)	2365	557	76
Mix 1:1 ethanol (commercial) + contaminated soil	2548	152	94
5 min of propane burning	2480	1547	38
2.5 cm methanol gel	2075	1847	11

Large-Scale Burning

- Canadian Forces Base Gagetown
- Wellington range : active antitank range
- Gel spread and mixed with soil
- Samples taken before and after the burning
- Analyses by HPLC (in-house method based on EPA 8330b)

Burning Test at Wellington Range



Efficiency of the Thermal Treatment at Wellington Firing Position

Setup	Reduction % of the NG concentration		
	%	Average	Standard deviation
Surface (0-1 cm deep) samples			
Gel poured directly on soil	26	50	30
	25		
	80		
	60		
Soil mixed (5 cm deep) before the gel was added and mixed in the softened soil	89	87	3
	85		
Soil mixed (5 cm) deep. Gel was poured on top	83	84	2
	86		
Subsurface (2 cm deep) samples			
Gel poured directly on soil	56	20	30
	1		
	49		
	-14*		
Soil mixed (5 cm deep) before the gel was added and mixed in the softened soil	31	40	10
	51		
Soil mixed (5 cm) deep. Gel was poured on top	21	21	3
	25		

Results and Future Work

- Results : A gel-type fuel based on ethanol is efficient : more than 80% reduction of NG in the first 2 cm of soil
- Most of the heat is directed upwards
- Need to determine :
  - Gaseous emissions
  - Effects of: soil humidity, organic content, soil size fraction, presence of winds, temperature, etc.
- Procedure could be used on a regular basis to avoid build-up and transport in the deeper layers of soil
- NOT a decontamination procedure for a large site and deep contamination

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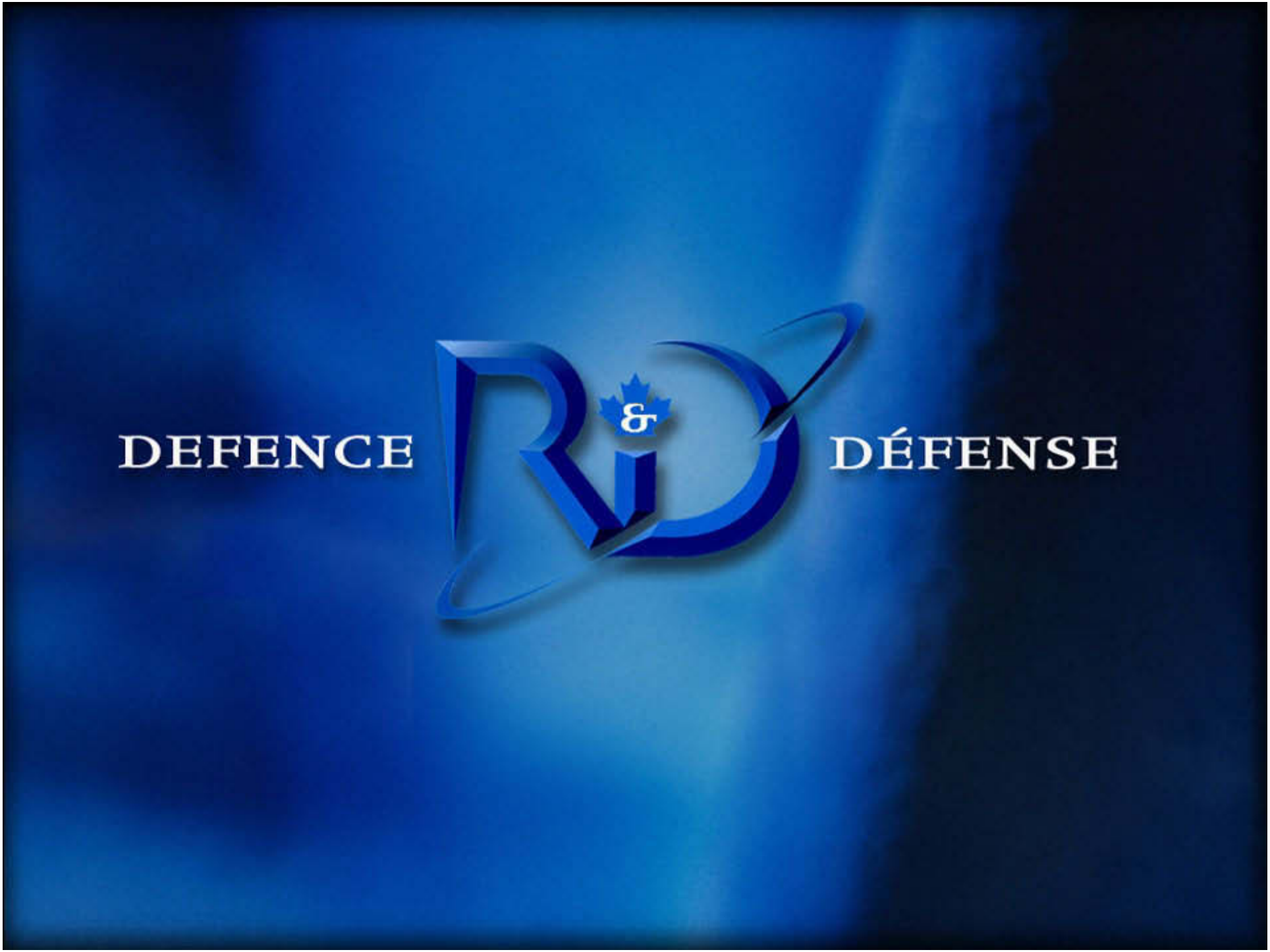
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